# BEAGLE 2 THE MOON: AN EXPERIMENTAL PACKAGE TO MEASURE POLAR ICE AND VOLATILES IN PERMANENTLY SHADOWED AREAS OR BENEATH THE LUNAR SURFACE

E.K. Gibson[1], D.S. McKay[1], C.T. Pillinger[2], I.P. Wright[2], M.R. Sims[3] and L. Richter[4]. [1]KR, ARES, NASA Johnson Space Center, Houston, TX 77058, [2]Planetary and Space Sciences Research Institute, The Open University, Milton Keynes MK7 6AA, UK, [3]Dept. of Space Sciences, Leicester University, Leceister, UK and [4]Institute for Space Sciences, DLR, Bremen, Germany. [everett.k.gibson@nasa.gov]

NASA has announced the selection of several Lunar Science Sortie Concept Studies for potential scientific payloads with future Lunar Missions. The Beagle 2 scientific package was one of those chosen for study. Near the beginning of the next decade will see the launch of scientific payloads to the lunar surface to begin laying the foundations for the return to the moon in the Vision for Space Exploration. Shortly thereafter, astronauts will return to the lunar surface with the ability to place scientific packages on the surface that will provide information about lunar resources and compositions of materials in permanently shadowed regions of the moon (1). One of the important questions which must be answered early in the program is whether there are lunar resources which would facilitate "living off the land" and not require the transport of resources and consumables from Earth (2). The Beagle science package developed to seek the signatures of life on Mars is the ideal payload (3) to use on the lunar surface for determining the nature of hydrogen, water and lunar volatiles found in the polar regions which could support the Vision for Space Exploration.

Beagle packages can operate with minimal human interaction or completely autonomously on the lunar surface. This system is analogous to the ALSEP (Apollo Lunar Surface Experiment Packages) instruments used on the Apollo missions. The adaptation for sortie missions of scientific payloads developed for other planetary missions, such as the Beagle 2 science payload, has the major advantage of having already established resource requirements (i.e. mass, power and data transmission rates) and costs (3). A lunar modification should only decrease these requirements because of the elimination of the entry aeroshell, the vacuum system and possibly other components that are unnecessary in more controlled landing scenarios.

The Beagle 2 payload was designed to operate on the Martian surface in a completely autonomous manner (3). Once deployed on the lunar surface, it would require minimal crew interaction. Its size also allows for inclusion with a lunar rover mission. The key instruments include a magnetic sector mass spectrometer to analyze volatile species [H, D/H, water abundances and other potential carbon containing molecules (hydrocarbons?) (4,5) trapped in cold regions of the moon], instruments for assessing elemental composition of the lunar soils and rocks, and a range of spectrometers capable of fully determining rock and soil mineralogy. The Gas Analysis Package (GAP) instrument suite (Fig. 1) was the most sophisticated mass spectrometer ever sent to Mars or the moon, and the first with a real chance of documenting isotopic biosignatures in the soil and rock record. Application of the Beagle technology to answering the lunar hydrogen and $H_2O$ question seems obvious. With the presence of a vacuum on the moon, operation of the Gas Analysis Package and the mass spectrometer should be facilitated and the payload should be able to be reduced in mass and power requirements significantly from the baseline Martian design.

*Best of all, the Beagle instrument package has already been designed, built, extensively tested in the laboratory, and flight qualified for the mission to Mars. Extensive testing already done on Earth can be used for evaluation of the Beagle concept applied to the moon.*

One of the key goals of the Human Exploration Program and the Vision for Space Exploration is to return to the moon and have lunar surface activities that consist of a balance of science, resource utilization, and "Mars-forward" technology and operational demonstrations. Utilization of the technology developed for the Beagle 2 spacecraft fits perfectly into the goals outlined. The instrumentation onboard the Beagle 2 spacecraft with its Gas Analysis Package (GAP) and Position Adjustable Workstation (PAW) sampling arm can provide answers to the science (for example *in situ* noble gas exposure ages) and resource questions (3). The primary Beagle 2 sampling device (MOLE) can obtain subsurface samples as deep as two meters and would be ideal for seeking out subsurface ices (3). The Gas Analysis Package can provide answers to the questions of concentrations of hydrogen (5) in the lunar polar regions, possible ice concentrations beneath the surface in polar regions (1), and provide direct abundances and isotopic compositional measurements of any trapped meteoroid or cometary volatiles in the permanently shadowed regions (3). Isotopic compositions of the hydrogen will assist in the identification of the origin of the hydrogen (possibly from the solar wind or cometary). These measurements will provide keystone data points which can be utilized in answering the lunar resource availability question and assist in the planning for "living off the land concepts" (2).

The Beagle GAP with its mass spectrometer and sample arm, either as a self contained ALSEP-like package or a small payload for utilization on a lunar rover, offers the most viable option for determining whether the polar regions contain $H_2O$ in either chemically bound water or as ice in permanently shadowed regions or beneath the surface. The payload is currently under study as to whether it could provide vital information which would allow the go ahead for developing a lunar payload for use in the future landed payloads or with lunar rover missions.

The potential of Beagle 2 for NASA's future Moon exploration activities has been recognised by its selection, through a peer review process, for concept studies as part of the NASA lunar sortie science opportunity concept study. Beagle 2 enjoys support from a consortium of university and industrial partners: Aberystwyth, Birkbeck, EADS-Astrium, DLR, JSC Houston, Leicester, MSSL, Open University (PSSRI + Earth Sciences + Chemistry), Rutherford Atomic Laboratories, Roke Manor, SEA, SSSL, SSTL with others, including US groups, under consideration.

## References:

[1] Arnold, J.R.,(1979) JGR, **84**, 5659-5667. [2] Schmitt H.H., et.al. (2000) *SPACE 2000, 7th International Conf. and Exposition on Engineering, Construction, Operations, and Business in Space*, Albuquerque, NM. Proceedings pp. 653-660. [3] Pillinger C.T. (2003), *The Guide to Beagle 2*, The Open University, Milton Keynes, UK. 222 p. [4] Gibson E.K., Jr. and Chang S.(1992): *Exobiology in Solar System Exploration* 28-43, NASA SP-512. [5] Bustin R. and Gibson E.K. (1992) *2nd Conf. of Lunar Bases and Space Activities of the 21st Century*. NASA Conference Publication 3166, Vol **2**. 437-445.

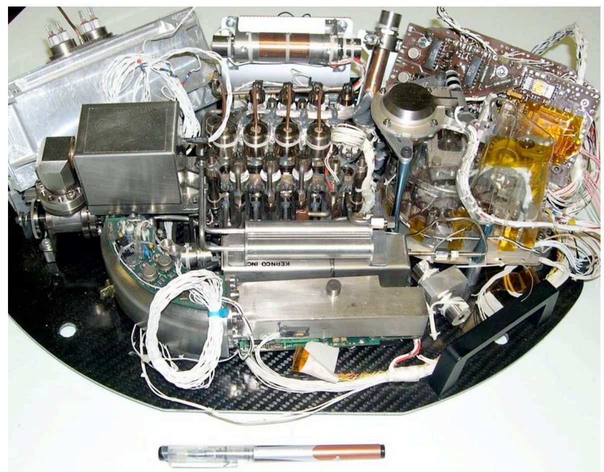

Fig. 1. Gas Analysis Package from Beagle. Pen length is 14.5 cm (6 inches).